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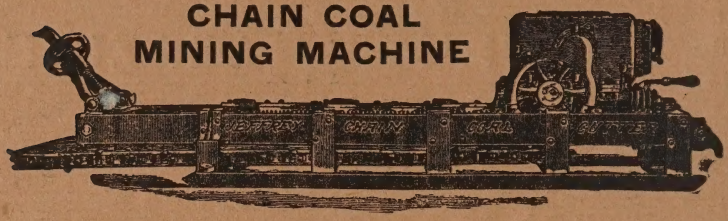

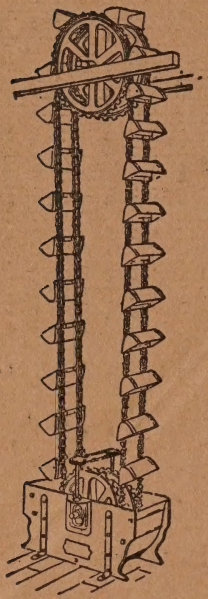

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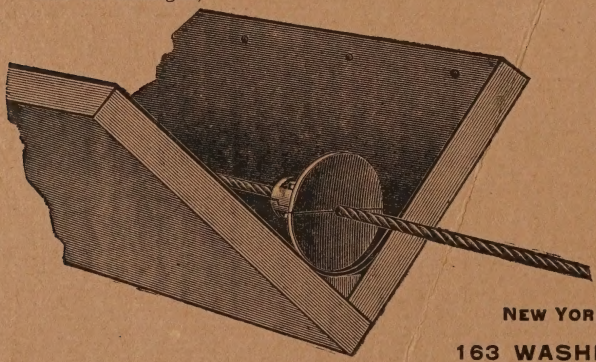

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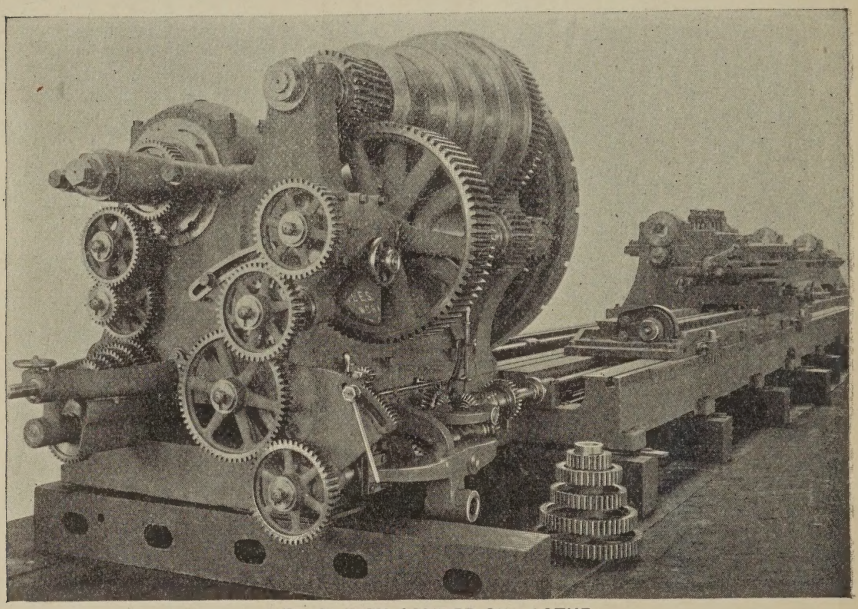

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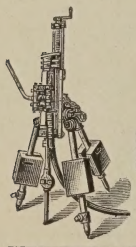

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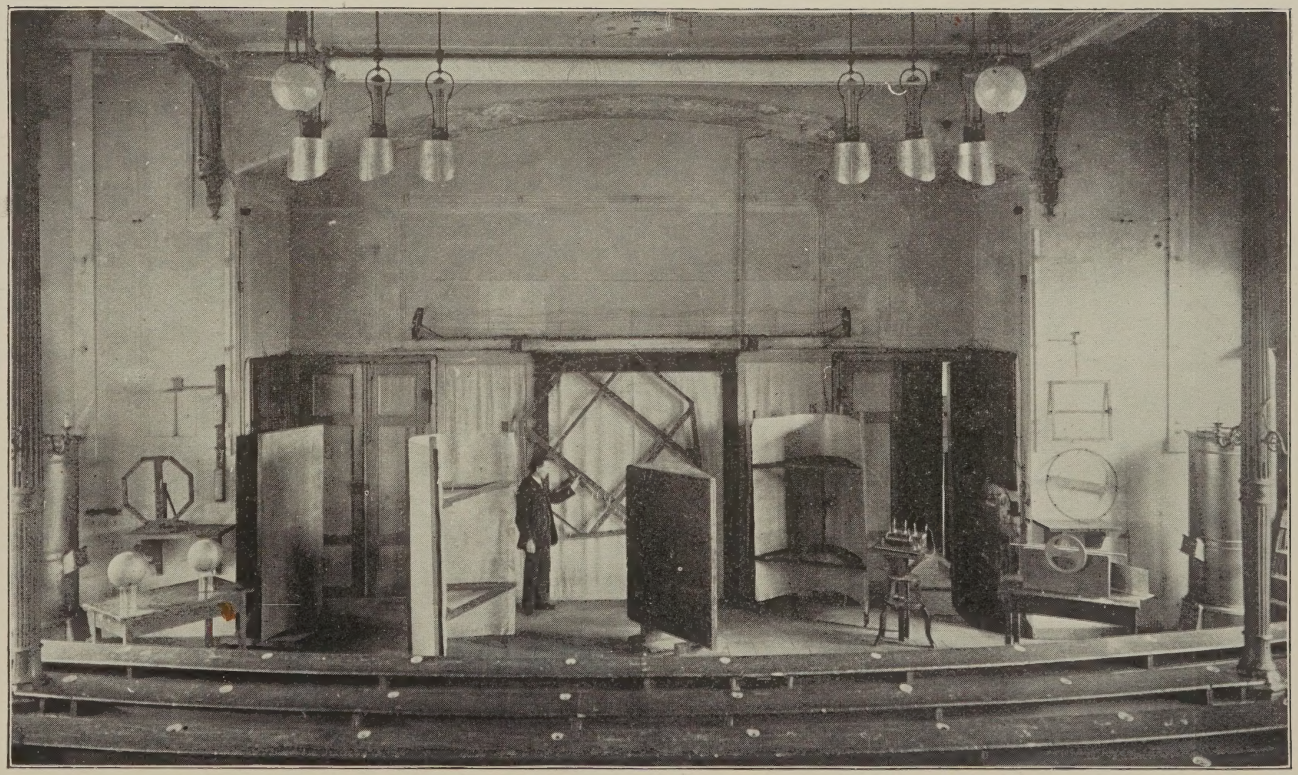

LECTURE-ROOM IN THE TECHNICAL COLLEGE AT CARLSRUHE, WHERE HERTZ PERFORMED HIS EXPERIMENTS.

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KNOXVILLE, TENNESSEE, AUGUST, 1896.

HERTZ' EXPERIMENTS ON THE ELECTROMAGNETIC THEORY OF LIGHT.

By Dr. Chas. A. Perkins.

THE industrial applications of electricity have had an astonishing growth within recent years, but the enlargement of our knowledge of the nature of electricity itself, and its relation with various physical forces, has been no less remarkable.

Faraday was the first to prove the intimate connection between electricity and light, showing that the plane of polarization of light is rotated by an electric current, somewhat as it is rotated when passing through a sugar solution. Faraday further ventured the suggestion that light itself might be an electrical vibration, and that electrical and magnetic forces might be exerted by means of the luminiferous ether, "for it is not at all unlikely that, if there be an ether, it should have other uses than simply the conveyance of radiations." These ideas of Faraday were submitted to mathematical tests by Maxwell, who found them capable of explaining and accounting for the facts, and upon them he based his well known electromagnetic theory of light.

Everyone who has used a telephone is familiar with the fact that when variable electric currents are passing along a wire, currents are thereby set up in the parallel telephone wire. Maxwell showed that if such a disturbance traveled as a wave from one wire to the other through the air, it should travel with the velocity of light. Maxwell's theory is, in short, that light is itself such a wave of magnetic induction. According to this theory, light is produced by rapidly alter-

nating currents in the luminous body, the direction of the currents being reversed about one thousand million million times per second. Several of the optical properties of bodies can be explained by this theory, especially the extreme opacity of metals; and so strong was the evidence in its favor that the theory was considered by scientists to be highly probable, even in the absence of direct experimental proof, Indeed, currents of such a high rate of alternation are not to be measured by any ordinary electrical apparatus, nor is it easy to experiment upon the velocity of a wave which travels (as does light) with a velocity of 186,000 miles in a second.

Direct experimental evidence was first obtained eight years ago by Prof. Hertz, in the following way:

Two conductors were placed very near each other and connected, one to each electrode of an induction coil, so that when the coil was in operation sparks should pass from one conductor to the other. Under these circumstances the electricity does not simply jump across the gap and come to rest, but vibrates back and forth in a series of sparks which follow each other at a rate depending upon the shape and size of the conductors used. For those first employed by Hertz they succeed each other at the rate of one hundred million per second. Of course there are not one hundred million sparks—perhaps half a dozen, but these follow each other at this rate. On holding near these sparking conductors a ring or rectangle of wire in which was a break at one point, sparks were seen at this break whenever they occurred between the conductors, showing that the electrical vibration had the same power as an electrical current to induce a current in a neighboring wire. Having calculated the number of vibrations per second in these wires, the next question was whether the induction traveled as a wave, or whether the current was produced by the electrical vibration acting directly and instantly upon the wire.

A large sheet of zinc was hung upon the further wall of the room to reflect the wave of induction, if it were a wave, and as a result it was found that at regular distances from the sparking conductors, the induced spark in the wire could not be obtained, while at intermediate points it was intensified, just as when waves upon the surface of water are reflected back, there are certain points where the surface is at

rest, while between these points the water rises and falls in a wave more vigorous than before.

Hertz thus found evidence of the existence of a wave of induction, and succeeded in measuring its length, and from the wave length and the number of vibrations per second, he calculated its velocity. This velocity proved to be, as nearly as his experiments would show, equal to the velocity of light.

To further study the similarity between this electrical wave and light, Hertz made two large parabolic mirrors of sheet zinc. In the focus of one of these he placed the two conductors which were in connection with the induction coil; in the focus of the other he placed two similar conductors, between which a spark would jump when they passed between the first pair.

The mirrors were placed facing each other and acted perfectly as reflectors, concentrating the wave and causing a vigorous sparking in the second pair of conductors. Metallic screens placed between the mirrors showed that the wave traveled in a straight line. By a large prism of pitch the wave was bent out of its course as a beam of light is refracted.

So complete was the similarity of the electrical wave to that of light, that not a doubt remains in the mind of any physicist as to the identity, or at least the close connection, of the two.

The extreme interest and importance of these experiments led the writer of this article to desire a picture of the lecture room in the Technical college at Carlsruhe, Germany, where the experiments were carried on. Through the great courtesy and kindness of Dr. Lehmann, successor to Prof. Hertz in this institution, such a picture has been obtained, and a copy forms the frontispiece of this magazine. The room has been restored, as far as possible, to its condition at the time of the experiments, and such of Prof. Hertz' apparatus as still remains intact is shown in the cut. The large reflectors are shown in position, with the prism of pitch placed between them, to determine its refractive power. The circles and rectangles of wire, reflecting sheets of metal, a large wooden frame on which are strung wires for experimenting on the "polarization" of the wave, are all shown. The man who is represented holding this large frame in his hand is Mr. Amann, who assisted Prof. Hertz in carrying out his measurements. The picture also shows the stoves and iron columns at the sides of the room, which Prof. Hertz afterward believed had introduced certain errors into some of the measurements.

THE OCCURRENCE OF TITANIUM.[1]

By Prof. Charles E. Wait, Ph. D.

IT is not my present purpose to repeat what has been already frequently published relative to the presence of titanium in minerals, typical rocks, meteorites, clays, soils, blast furnace products, etc. I wish merely to call attention to the fact that some of the bodies with which we have much to do contain titanium, and that probably owing to the difficulties formerly experienced in its estimation, it has been more frequently overlooked than is generally supposed.

In the recent examination of food materials, under the direction of the United States Department of Agriculture, I have had occasion to make analyses of the ashes of some plant materials, and this having led to further investigations, I was interested and suprised to find titanium present in every plant ash thus far examined.

This is in fact surprising, as it is stated by some writers[2] that "it does not appear to form part of the animal or vegetable kingdom."

The amount of titanic oxide found in the ash of some vegetable material is as follows:

	Per cent.
Oak wood	0.31
Apple and pear wood mixed	0.21
Apple	0.11
Cow peas	0.01
Cottonseed meal	0.02

From the above determinations we are reasonably safe in assuming that titanium is assimilated by plants. If this is true, it seems very strange that reference to this fact has not been made by recent writers upon agricultural chemical analysis, and upon the chemistry of vegetable life.

In fact, in consulting treatises on ash analysis with tables,[3] I do not find any mention whatever of the presence of titanium. If this is a fact, can it be true that it has escaped the attention of chemists for so long a time?

[1] Reprinted from the Journal of the American Chemical Society, Vol. XVIII., No. 4. April, 1896.

[2] Roscoe & Schorlemmer.

[3] Wolff.

The examination of the ash of bituminous and anthracite coal shows the presence of titanic oxide. The results of some determinations are as follows:

	Per cent.
Jellico (Tenn.) bituminous coal	0.69
Coal Creek (Tenn.) bituminous coal	0.95
Pocahontas (Va.) bituminous coal	0.94
Middlesborough (Ky.) bituminous coal	0.83
Pennsylvania anthracite coal	2.59

With reference to the presence of titanic oxide in the ash of coal, it may be fairly assumed that partly owing to the infiltration of clay and earthy materials, it would be found there, but is it fair to assume that its presence is wholly accounted for in that way? If mention has been made of the presence of titanium in the ash of coal, it has thus far escaped my attention.

The method employed in the above determination is that of A. Weller, which is based upon the fact that hydrogen peroxide, when added to a solution of titanium, produces a compound of an intensely yellow color. There are precautions necessary in the execution of this method which have already been pointed out.

It will be my pleasure to report additional notes at an early day concerning the presence of titanium in the vegetable kingdom. Valuable service has been rendered in the above work by Messrs. J. O. LaBach and C. O. Hill

UNIVERSITY OF TENNESSEE.

NOTES ON THE ZINC DEPOSITS IN TENNESSEE.

By W. H. Gildersleeve.

TENNESSEE is not generally classed as a zinc-producing State, and comparatively little is known about its deposits. While the production of zinc in this State is insignficant when compared to that of the zinc districts of foreign lands, or that of Missouri, Wisconsin, and New Jersey, yet there occur in the eastern part of the State some deposits of ore of excellent quality, and, as far as developed, promise to be of considerable value.

The zinc deposits of Tennessee are mainly in the Valley of East Tennessee. Sphalerite, or blende, is found in connection with galenite in Johnson and Union counties, and near Cleveland, but in the more important deposits the ores of lead are absent. They are found in the Knox dolomite, which extends from the Virginia line, through the Valley to the Georgia line. Indications of ore have been found all along the trend of the dolomite, but apart from the two or three openings which will be mentioned later, no deposits of value have been discovered.

The deposits in Union and Claiborne counties have been long known. About one-half mile from Powell's river, in Union county, occurs a very fair deposit, but it has been worked very little. The following description of this region is taken from Safford's Geology of Tennessee, page 487. "The ore outcrops in a belt or zone, which is from fifty to sixty feet wide, and runs in an east-northeasterly direction across a low ridge. This zone has always been marked out by the absence of trees. Over the area, six or seven pits were dug many years ago, and a dozen tons of ore thrown out. The ores smithsonite and calamine, with here and there buttons and small masses of galenite, and occasionally sphalerites occur with much siliceous matter, in irregular veins. The veins are from a few inches to several feet in thickness. The rocks of the vicinity are dark and blue magnesian limestone of the lower part of the Knox dolomite. The strata in general are approximately horizontal." The ore from this mine was ship-

ped for several years down the river to Clinton to the smelter at that place. But since that furnace closed down, about five years ago, nothing has been done with this ore. Near Tazewell occurs another small deposit. About five miles south of Cleveland, at Blue Springs, the zinc occurs along with the lead, and is mined to a limited extent.

ZINC MINE NEAR NEW MARKET, TENN. (Looking West.)

The deposits at Mossy Creek and New Market, in Jefferson county, are thus far the most important, and the latter, although just lately opened and comparatively undeveloped, promises to be the most valuable occurrence in the State. The opening of the deposit at New Market is about two miles east of the station on the Dandridge pike. The deposit is opened on the north side of the pike and extends up a small valley at right angle to the valley of Lost Creek, and tributary to it. The water in the latter is utilized in separating the ore from the gangue. In wet weather there is considerable underground water in the valley where the deposit occurs, but there is no surface stream. The presence of zinc there

has been known to one or two persons for some time, but it was not generally known until the party interested could get possession of the property. This was done in the Fall of 1895, and immediately prospecting was begun with fair results. Like most other zinc deposits, this one occurs in dolomite—the Knox dolomite. This dolomite is crystalline and dark blue in color at that place. The general strike is northeast. The deposit at Mossy Creek seems to occur in the same ledge, while those of Union and Claiborne counties are to the west of it. The dip of the rock at New Market is between 37° S., and nearly horizontal. The ore occurs toward the base of the series, apparently in the Cambrian system. In some places there are indications of faulting.

The deposit at New Market is at least fifty feet wide at the surface, but the length and depth are not known. The deepest opening in April, 1896, (since then work has been going on quite steadily), was only about twenty feet, and the quality seems to increase with the depth. Sphalerite, smithsonite, and calamine are all found, the calamine being quite scarce. The smithsonite seems to predominate at the surface, and decrease in quantity with the depth, while the reverse is true of the sphalerite. This would indicate that at one time the whole deposit existed as sphalerite, and near the surface it has been changed to smithsonite by aqueous and atmospheric agencies. The sphalerite being first changed to zinc sulphate, which in turn was changed to smithsonite, the carbonate. Such is probably the case here. The sphalerite occurs very pure. At first only very small pieces were mined, but now blocks of pure sphalerite, between two and three feet on an edge, are taken out. It has a waxy lustre and yellow color. As exposed, it occurs in parallel veins, with cross veins intersecting. The veins increase in size with depth, varying from one-fourth inch to three feet in thickness. The gangue is crystalline dolomite, but calcite frequently occurs. Some of the veins have the appearance of having been separated, and small "horses" of dolomite formed.

The smithsonite occurs in veins, sometimes in contact with the sphalerite, and sometimes separate. It has a yellowish color, with sometimes a blue tinge. The calamine, when present, occurs along with the smithsonite.

Below are given the results of analyses of the ores made at the University of Tennessee:

SAMPLE OF SMITHSONITE FROM NEW MARKET.

SiO_2	13.10%
$FeO.\ CO_2$	1.32 "
Fe_2O_3	.66 "
$CaO.\ CO_2$	1.07 "
$MgO.\ CO_2$	.56 "
$ZnO.\ CO_2$ (by difference)	83.29 "
	100.00 "

SAMPLE OF SPHALERITE FROM NEW MARKET.

SiO_2	7.57%
Fe_2O_3, Al_2O_3	1.66 "
$CaO.\ CO_2$	5.98 "
$MgO.\ CO_2$	.04 "
ZnS (by difference)	84.75 "
	100.00 "

SAMPLE OF SMITHSONITE AND CALAMINE FROM MOSSY CREEK.

$Si\ O_2$	19.09%
Fe_2O_3	.70 "
Al_2O_3	2.15 "
$CaO.\ CO_2$	4.34 "
$MgO.\ CO_2$	3.17 "
$ZnO.\ CO_2$	28.81 "
$(ZnO)_2\ SiO_2.\ H_2O$	40.49 "
H_2O and losses	1.25 "
	100 00 "

Around on the near-by hills are numerous diggings where people have been prospecting on their own land, and it is possible that other valuable deposits may be found in that locality. The owners of the opened deposit have erected a separator at the mine, which began operations in the latter part of May, 1896. After separation, the ore is shipped to Indianapolis, where the owners have an extraction plant. During May (1896) there were about three carloads of ore being shipped in a week, but since the separator is now in operation the shipments will increase. As suitable labor for smelting works would hardly be procurable in Tennessee, it is found by experienced operators of zinc mines to be more economical to ship the ore away than to erect a smelter at the mines.

The old mine at Mossy Creek is in the town, and near the

Southern Railroad—the railroad crosses the vein at the edge of town. As said before, this deposit seems to occur in the same ledge as the one at New Market. However, the dolomite at Mossy Creek seems to be fractured more than that at New Market. In general the mode of occurrence at the two places is the same. The most important ore at Mossy Creek was the smithsonite. The deposit seems to have given out before a sufficient depth was reached to find the unchanged sphalerite. This mine has not been worked for sometime. Since the discovery at New Market, however, the interest in zinc at Mossy Creek has revived, and as a result there is considerable prospecting with the hope of finding a deposit better than the one formerly worked. Up to the first of May, (1896), one company had dug between one hundred and fifty and one hundred and sixty pits from twelve to fifty feet deep. They had found no fair indications near the town until the last four or five holes dug, about one-fourth mile north of the railroad. However, better indications have been found about two and one-half miles north of the town.

There is a plant at Mossy Creek for the separation of the ore from the gangue, and for the manufacture of zinc-white, but this has not been in operation for some time. When the mine was in operation most of the ore was shipped to Virginia and Clinton, Tennessee.

The deposits in Tennessee, thus far opened, have not been worked so extensively as those of other States, and the output, therefore, is comparatively small; but the openings at New Market and Mossy Creek have fair prospects of a large output, if they are developed, and Tennessee may yet become an important zinc-producing State.

CHARLES A. PERKINS, Ph. D.

Professor of Physics, University of Tennessee.

DR. CHARLES A. PERKINS,

PROFESSOR OF PHYSICS AND ELECTRICAL ENGINEERING.

CHARLES A. PERKINS, Professor of Physics at the University of Tennessee, was born in Ware, Massachusetts, October 31st, 1858. His father and grandfather were Congregational ministers, and members of that sturdy Puritanic stock which first settled the bleak coast of Massachusetts, and laid the foundations of the American republic. He is a direct descendant of Captain Miles Standish, and therefore enjoys the distinction of being able to say that his ancestors came over in the Mayflower.

His early education was thorough, and was obtained at the public schools of his native village, where, too, he was prepared for college. At the age of sixteen he entered Williams College. There he had for one of his instructors the celebrated Mark Hopkins, of whom Garfield once said: "This peerless teacher on one end of a log and a student at the other, would constitute a college, even in the wilderness!"

He graduated with the degree of A. B. when twenty, and at once entered the profession of teaching, for during the following year he took his brother's place as Professor of Mathematics in Lawrence University, Appleton, Wisconsin, the Methodist college of that State.

Dr. Perkins began his post-graduate study at Johns Hopkins University in 1881, having received a scholarship in December of that year. The following year he was granted another scholarship, and the third year a fellowship. His thesis was entitled "The Magnetic Permeability of Nickel," which was published by the Johns Hopkins University. After taking the degree of Ph. D., he was invited to remain as instructor of physics, which position he held for three years. This fact indicates the high estimation in which his scholarship and ability were held by the University authorities. Leaving Johns Hopkins, he went to Bryn Mawr College to take charge of the department of physics. There he remained until 1891. In 1892 he was elected Professor of Physics in the University of Tennessee, and entered upon his work in September of that year.

Dr. Perkins is an enthusiastic student, and is fully alive to every invention or discovery in the line of physics. He is, himself, constantly engaged in original investigations. His exceptional educational opportunities, and his untiring energy, have fitted him well for his chosen field of labor. He spent the summer of 1891 at practical work in the Thompson-Houston electrical works, at Lynn, Mass., and the summer of 1889 was spent in visiting laboratories in Germany, and in studying methods employed therein.

Messrs. Henry Holt & Co. are to bring out a volume by Dr. Perkins, entitled "Outlines of Electricity and Magnetism." The explanations are based upon Faraday's lines of force, and Maxwell's conceptions of forces exerted by the action of electrified bodies. The book is not a complete treatise; but short and clear descriptions of the essential phenomena and their teachings give the student an outline of the whole science. The arrangement of the book has already received the commendation of experienced teachers, and its general treatment is perhaps more up to date than that of any text-book on electricity now in use.

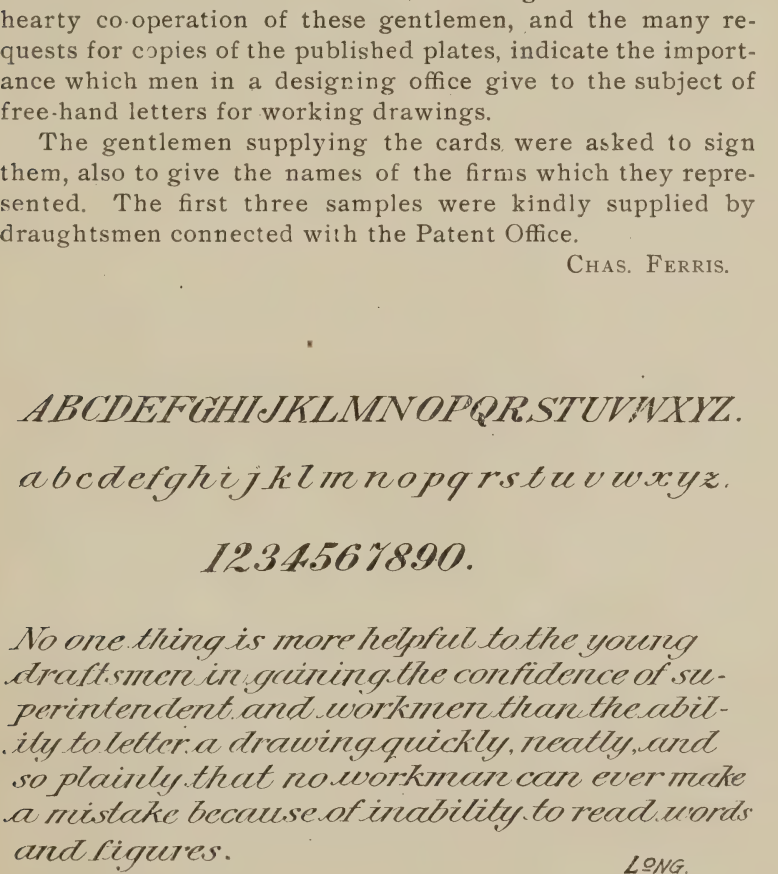
A recent invention of Dr. Perkins is an improved bicycle dynamometer. Patents have been applied for covering the fundamental principles of such dynamometers, and after some experiments, he has devised a form of that instrument which may be readily used to test the work required by different machines, as well as the effect of speed, grades, road, material, etc., and tests on these points are expected to show interesting results this summer.

FREE-HAND LETTERS FOR WORKING DRAWINGS.

LITTLE need be said in connection with the following samples of free-hand letters. The writer sent a circular letter to the chief draughtsmen of a number of large manufacturing establishments asking for sample cards of letters representing what experience had shown to be the best style for working drawings. The cost of making, legibility, and neatness were to be considered in making the choice. The hearty co-operation of these gentlemen, and the many requests for copies of the published plates, indicate the importance which men in a designing office give to the subject of free-hand letters for working drawings.

The gentlemen supplying the cards were asked to sign them, also to give the names of the firms which they represented. The first three samples were kindly supplied by draughtsmen connected with the Patent Office.

CHAS. FERRIS.



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Rand McNally & Co. Chicago.
A. van der Grinten, draftsman.

ABCDEFGHIJKLMNOPQRSTUV
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The above Alphabets were made in about 12 Minutes without any Attempt at Correcting. They represent the Standard Lettering used in the Illustrations of "Engineering News" and form the Basis of the Styles shown in the Writer's Book on Freehand Lettering — Actual One-Stroke Lettering.

Chas. W. Reinhardt.
Chief Draftsman, Engineering News Publishing Co

DRAWING ROOM

BALDWIN LOCOMOTIVE WORKS.

Standard Letters & Figures.

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj

Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt

Uu Vv Ww Xx Yy Zz & 1234567890.

Aa Bb Cc Dd Ee Ff Gg Hh Ii Jj Kk Ll Mm Nn Oo Pp Qq Rr Ss Tt

Uu Vv Ww Xx Yy Zz & 1234567890. Practice makes perfect.

ABCDEFGHIJKLMNOPQRSTU
VWXYZ

A B C D E F G H I J K L M N O P Q R S T U
V W X Y Z
1 2 3 4 5 6 7 8 9 0

THIS LETTERING IS DONE WITH A WRITING STICK OF BOX-WOOD GROOVED TO HOLD THE INK.

BROWN & SHARPE MFG. CO.
PER GEO. H. NEWTON.

a b c d e f g h i j k l m n o p q r s t u v w x y z
A B C D E F G H I J K L M N O P Q R S T U
V W X Y Z.

No one thing is more helpful to the young draughtsman in gaining the confidence of superintendent and workman than the ability to letter a drawing quickly, neatly, and so plainly that no workman can ever make a mistake because of inability to read words or figures.

ABCDEFGHIJKLM
abcdefghijklmnopqr
1234567890

"A draughtsman is judged by his lettering."

Clarence White
with
Geo. F. Barber & Co.
Knoxville, Tenn.

ABCDEFGHIJKLMNOPQRSTUV

abcdefghijklmnopqrstuvwxyz &

1234567890

CHAS. W. BARRETT

WITH

'TIS WISE,
IN LETTERING A DRAWING
WHICH MAKES IT LOOK FINISHED,
TO MAKE LETTERS THAT LOOK NEAT
WHETHER LARGE OR DIMINISHED
IN SIZE.

GEO. F. BARBER & CO., ARCHITECTS,
KNOXVILLE TENNESSEE.

ABCDEFGHIJKLMNOPQRS

abcdefghijklmnopqrstuvwxyz

1234567890

ROBERT D. RICHARDS

WITH

GEO. F. BARBER & CO.

KNOXVILLE TENNESSEE

DRAWING ROOM.

BALDWIN LOCOMOTIVE WORKS.

STANDARD LETTERS & FIGURES.

AA BB CC DD EE FF GG HH II JJ

KK LL MM NN OO PP QQ RR SS TT

UU VV WW XX YY ZZ && 1234567890.

1234567890.

ABCDEFGHIJKLMNOPQRSTU

VWXYZ

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W.C.Bolgiano.

EDGE MOOR BRIDGE WORKS.

Sample of Title for Drawings

96 IN BORING MILL

DRIVING GEAR & FEEDING MECHANISM

SCALE 3 IN = 1 FT

WM SELLERS & CO. INC'D.

ORDER No.

H. BACON

JUNE 9 - 1896.

DRAWING No. 15061

ABCDEFGHIJKLMNOP
QRSTUVWXYZ &

ABCDEFGHIJKLMNOPQRSTU
VWXYZ& 1234567890

WM SELLERS & CO. INC'D.

PHILADELPHIA PA.

H. BACON.

AS A PLAIN EASILY ACQUIRED LETTER
WHICH CAN BE MADE FREE-HAND WITH THE
RIGHT-LINE PEN WE HAVE ADOPTED FOR
ALL NOTES THIS STYLE OF GOTHIC.
ABCDEFGHIJKLMNOPQRSTUVWXYZ&
1234567890

FOR FREE-HAND TITLES
With T-square used in Shading
AaBbCcDdEeFfGgHhIi
JjKkLlMmNnOoPpQqRr
SsTtUuVvWXxYyZz

ABCDEFGHIJKLMN
OPQRSTUVWXYZ.
ABCDEFGHIJKLMOPQRSTUV
WXYZ.
1234567890.

M.C. PIERCE
EDGE MOOR BRIDGE WORKS

ABCDEFGHIJ
LMNOPQRST
UVWXYZ&·
abcdefghijklmnopqr
stuvwxyz&· ———
1234567890· ———

Piers ———

—— Cofferdams etc· —

L·C·Carter, C·E·, Del·

A, B, C, D, E, F, G, H, I,
a, b, c, d, e-e, f, g, h, i,
J, K, L, M, N, O, P, Q, R, S,
j, k, l, m, n, o, p, q, r, s,
T, U, V, W, X, Y, Z, &
t, u, v, w, x, y, z, &

1, 2, 3, 4, 5, 6, 7, 8, 9, 0. 6'- 4 57/64"

Note;—

Pattern "10-T-30" to be altered by lengthening front projection of hub 9 7/16" to produce "10-T-43".

(By C. A. Boyd. Chf. Drsman Cleveland, Ohio. "Walker Company".)

TEST OF AN ISOLATED ELECTRIC LIGHTING PLANT.

By S. A. Beyland.

THIS article contains the results of tests of the gas engine and lighting plant belonging to the First M. E. Church, of Knoxville, and was made in order to ascertain the economy of such a plant in actual service as run by the janitor. No precautions were taken to have the machinery in better order than usual, and the gas was measured by the regular meter furnished by the gas company by which the bills were made out.

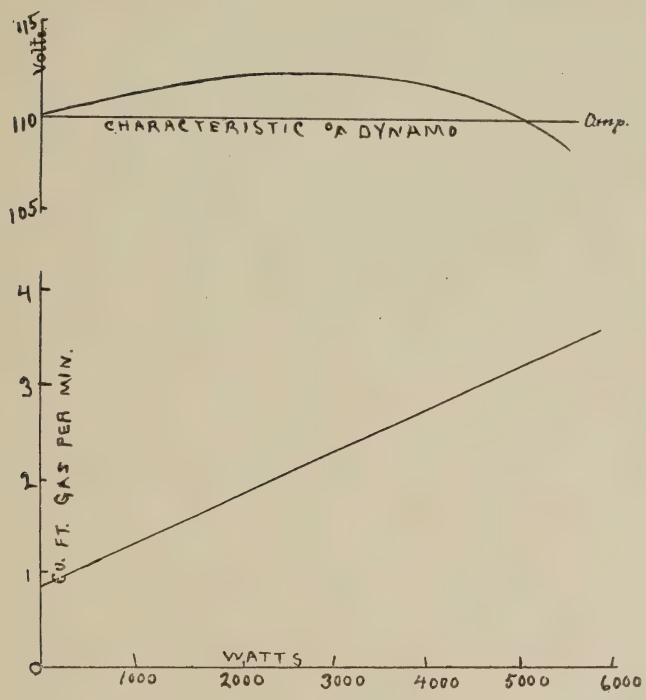
The tests were made by the engineering students of the University under the supervision of Dr. Perkins. They continued for about three hours.

Location: The engine and dynamo are located in the basement of the church, and in a cramped position between the wall and the furnace used for heating the building. During these experiments, on account of starting the fires, the temperature of the room rose from 60° to 82°.

The switch board was on the opposite side of the building from the dynamo, on the main floor, and all the branch circuits were fed from this point, thus introducing a large drop in pressure, as mentioned below.

Current and E. M. F. were measured by Weston instruments. The ammeter read only to 50 amperes. Above that point current was reckoned by the number of lamps in circuit. Speeds were measured by a tachometer, and quantities of gas by the meter in regular use furnished by the gas company.

The engine was the regular Otto 10-horse power machine, fitted with a governor controlling the speed by regulating the number of explosions. This governor worked well at high loads, but at very light loads the speed would frequently drop five revolutions or more below normal before an explosion would occur. The dynamo was rated at 110 volts and 60 amperes. It was compound wound, and the characteristic is shown in an accompanying diagram. For further regulation a rheostat is placed in the

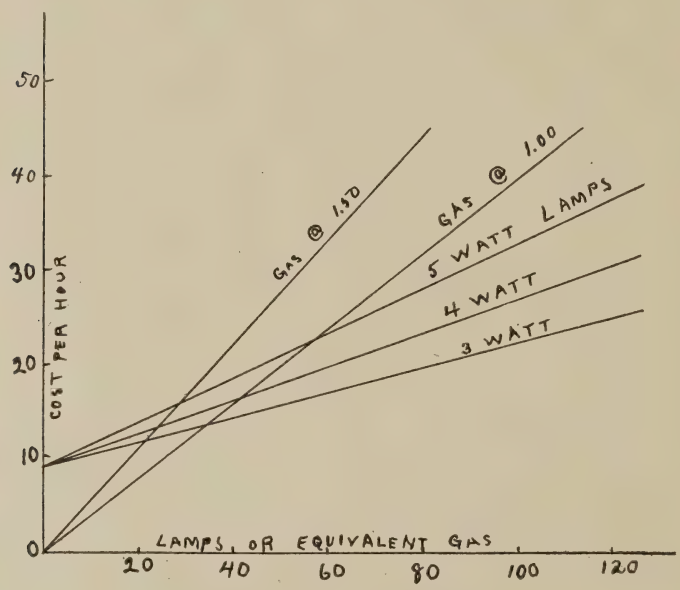


shunt field coils, which is cut out at high loads in order to compensate for the excessive losses in the feeders. The dynamo was run at a speed of about 1550 revolutions per minute. During the course of the test additional lamps were thrown on until the current rose to 70 amperes, while the temperature of commutator increased from 60° to 122°, the temperature of the room increasing during the same time to 82° as above mentioned. With a current of 50 amperes, a drop of 7.7 volts was noted between dynamo and switch-board, indicating a resistance of about 15 ohms. The wire was evidently too small, causing a loss of 1% for ten lamps, 5% for 50 lamps and 10% for 100 lamps. The loss in branch curcuits was also quite large, but was not determined, the lamps in the main chandeliers being inaccessible. The lamps used required about 80 watts; or 5 watts per candle power if we take them at their rated (16) candle power.

The consumption of gas above that necessary to run the

engine and dynamo unloaded increased quite uniformly with the load.

The accompanying figures show the cost of lighting per hour of actual plant for different loads, also cost for same plant if 4 watt lamps or 3 watt lamps were used. Lines are also drawn showing the cost of the same illumination using gas, the gas being taken at 20 c. p. as given by the regular tests of the gas company. The gas is reckoned at $1.00 per 1,000 cubic feet, and at $1.50 per 1,000 because the local company charges the latter price for gas used for illumination, while for gas engines and all fuel consumption they charge $1.00



From a consideration of the figure it will be seen that, where only a small number of lights is required, gas used directly is much cheaper. Above thirty lamps it is decidedly cheaper to use the gas for fuel in driving the dynamo. Thus if it is desired to illuminate but one or two of the smaller rooms, the gas burners are used, but if the main audience-room or the entire building is to be lighted, the dynamo is put in operation.

Number of Lamps	EXTERNAL			Cubic Ft Gas per Min.	Gas per Lamp Hour	Gas per Watt. Hour	Gas per 64 Watt. Hours
	E	I	W				
Engine with no load.....				1.25	.....	.....	.....
Belted to Dynamo—no current.....				1.54	.....	.....	.....
3	110.5	2.13	225	1.82	27.3	.485	31.0
31	112	22.6	2531	2.83	5.3	.067	4.23
51	112	38.0	4256	3.61	4.16	.051	3.26
71	110	(51.8)	5702	4.29	3.57	.045	2.88
67	110	49.0	5390	4.17	3.68	.046	2.94
80	108	.....	6296	4.35	.....	.....	.....
	Change	in rheo	stat shu	nt coil.	.....	.....	.....
	110	58.3	6471	4.84	3.58	.044	2.86
98	110	71.3	7843	5.36	3.25	.041	2.52

Current in shunt coil, 1.35 amp. Loss, 1.43 watts.

Drop to switch-board with 70 lamps, at 50 amp., 7.7 volts. Loss, 385 watts, or 17.3 c. f. gas per hour.

THE OXIDATION OF SILVER.[1]

By Prof. Chas. E. Wait, Ph. D.

IN a former paper[2] I had occasion to call attention to the large amount of silver present in a sample of bismuth litharge from a westerm smelting and refining company. The silver in this instance estimated in the metallic state was 2.94 per cent.

There was some doubt expressed as to the condition in which the silver existed, it being usually reported in the metallic state. Upon investigating it was found, as was shown in the paper referred to, that the silver did not exist wholly in the metallic state, but partly in another form, probably the oxide.

The conclusions reached at that time were based upon the following experiments:

1. A weighed sample of the litharge was boiled in acetic acid for about half an hour, the solution was filtered, and the filtrate gave no reaction for silver.

2. Same as above, but with continued boiling the filtrate gave no reaction for silver.

3. A sample was placed in cold acetic acid, kept there for half an hour, then heated to boiling, the solution was filtered, the lead was precipitated, and in the filtrate silver was found to exist, corresponding to 19.25 per cent. of the silver in the litharge. Other determinations gave closely agreeing results, and it is interesting to note that the residues contained grains of metallic lead, or argentiferous lead.

I have placed the following interpretations upon the above results:

In Nos. 1 and 2 if any silver in any form was dissolved in the acetic acid, it was in turn reprecipitated by boiling, in the presence of metallic lead.

In No. 3 the silver dissolved did not in all probability exist in the metallic state; and in this case was not precipitated by the lead, or argentiferous lead, the solution being brought merely to the boiling temperature.

[1] From the Journal of the American Chemical Society, March, 1896.
[2] Trans. Am. Inst. Min. Eng., 15.

I have been lead to the above interpretations by showing that neither metallic silver reduced to fine subdivision by mechanical means, nor silver freshly prepared by zinc from silver chloride, is soluble in acetic acid, while argentic oxide is soluble in that acid; and a solution of silver oxide in acetic acid was precipitated completely by metallic lead upon boiling.

If the oxides are decomposed at a temperature of 300° C.,[1] or less,[2] how may we account for the existence of this substance in a product so highly heated as the litharge from the refining furnace?

Berthier[3] has observed that lead may be oxidized by oxide of copper, when the two are melted together, and further consideration of the subject shows that certain metals may be oxidized by being melted with an oxide of another metal, this oxidation depending in all probability upon the excess of the oxide present. Silver does not appear to be oxidized by oxide of copper if the results in experiment No. 18, p. 35 of this paper, are trustworthy.

According to Fournet's experiments[4] silver is not an exception to the metals to which litharge gives up a part of its oxygen when fused with them for a considerable time.

While it is true that in the process of cupellation there is a loss of silver, due possibly to oxidation, yet I do not find any losses even in the most exaggerated cases at all comparable with the percentages of silver oxide which I have been able to produce by a simple, yet possibly new, method.

It seemed to me an interesting problem to ascertain, if possible, the conditions under which silver may be oxidized at a high temperature, and the conditions under which the oxide of silver, if thus formed, would remain as such.

Some interesting work has been done along a similar line,[5] that is, a study of those oxides which are stable at high temperature, and those which are decomposed, but under neither head does silver seem to have been discussed.

So few observations have been made along this exact line, as far as I have seen, that I have been induced to make some

1 Roscoe and Schorlemmer, Vol. II., Part I.
2 *J. Chem. Soc., 65, 316.*
3 Crookes and Rohrig, Metallurgy.
4 Erdman's Journal.
5 *J. Chem. Soc., April, 1894.*

investigations with a view to throw light upon the subject, if possible.

The general method of conducting the experiments, I will briefly state as follows: Metallic silver in minute subdivision was incorporated with one of the several bodies mentioned below, this mixture was put in a cupel of bone ash, or in a scorifier, and then placed in a muffle of an assay furnace and subjected to an oxidizing heat.

After this operation the mass was removed to a mortar, pulverized, then digested with cold acetic acid and the whole then raised to boiling, the solution was then filtered; in case a lead compound had been used, the lead was removed by sulphuric acid and hydrochloric acid was then added. The silver chloride thus formed was filtered, dried, and wrapped in a small piece of pure lead foil and then carefully cupelled.

There was thus obtained the silver, which was converted to argentic oxide,—at least I assume it to be such,—and it is interesting to note that the amount of silver converted to oxide, and tabulated below, shows a very great range, in fact from only a trace to as much as thirty-nine per cent. of the silver used.

This variation seems dependent upon a number of conditions, namely: the body with which the silver was mixed, duration and condition of heat, whether low, medium, or high temperature. As I did not use a pyrometer to ascertain the temperature during these experiments, I have thought it desirable to indicate the degree of heat approximately by such terms as "low," "medium," and "high," referring to the condition of the heat as usually obtained in the muffle in the assay of silver.

I append herewith several tables of experiments and results:

TABLE A.

No experiment	Ag. in gram.	Heated with	Time of heat	Condition of heat	Per cent. Ag. as Ag_2O.
1	0.5	2.5 grams MnO_2.	60 min.	medium.	9.40
2	0.5	5.0 " MnO_2.	60 "	"	7.78
3	0.5	2.5 " Fe_2O_3.	60 "	"	none
4	0.5	2.5 " Bi_2O_3.	60 "	"	"
5	0.5	2.5 " ZnO.	60 "	"	"
6	0.5	2.5 " $CaCO_3$.	60 "	"	"

From the above it will be seen that silver oxide was produced, and remained as such where manganese dioxide was used, and in no other case; it would also seem that this oxide was made at the expense of the manganese dioxide, and not by atmospheric oxidation, nor does it seem to have been produced in experiment 3, (certainly not remaining as such) assuming the possible conversion of Fe_2O_3 to Fe_3O_4.[1]

TABLE B.

No. experiment	Ag. in gram.	Heated with	Time of heat	Condition of heat	Per cent. Ag. as Ag_2O.
7	0.5	7.5 grams MnO_2.	30 min.	medium.	34.16
8	0.5	10.0 " MnO_2.	30 "	"	18.84
9	0.5	3.0 " $CaCO_3$	60 "	"	none
10	0.5	3.0 " Fe.	60 "	"	"

The above results show that silver oxide was produced in the presence of manganese dioxide only; that less duration of heat than in Table A gives the amazingly large per cent. of that oxide, and it furthermore seems that the oxide produced is not in proportion to the manganese dioxide used, but the reverse condition is generally seen in each set of experiments.

TABLE C.

No experiment	Ag. in gram.	Heated with	Time of heat	Condition of heat	Per cent. Ag. as Ag_2O.
11	0.5	1 gram MnO_2.	2.5 min.	high	32.24
12	0.5	2 grams MnO_2.	2.5 "	"	34.28
13	0.5	2 " MnO_2.	20 "	"	11.72

The above experiments show, other conditions being the same, the longer the duration of the heat the less oxide there is produced.

TABLE D.

No. experiment	Ag. in gram.	Heated with	Time of heat	Condition of heat	Per cent. Ag. as Ag_2O.
14	0.5	5 grams PbO.	10 min.	medium.	38.85
15	0.5	4 " PbO_2.	10 "	"	35.12
16	0.5	2 " BaO_2.	5 "	"	12.28
17	0.5	7 " BaO_2.	10 "	high	2.04
18	0.5	4 " CuO.	12 "	"	none

[1] *J. Chem. Soc., 65, 313.*

In Nos. 14 and 15 the mixtures were placed in scorifiers, and covered with ten grams of lead oxide.

In Nos. 16 and 17 the mixtures were placed in cupels and covered with two grams of barium dioxide.

It is interesting here to notice that barium dioxide serves as an oxidizing agent; that the amount of silver oxide produced decreases probably both with increase of time and temperature.

Although lead dioxide may readily give up a part of its oxygen and thereby be converted into a lower oxide, yet the amount of silver oxide produced was no greater than with lead oxide alone; this is an interesting illustration of the property of lead oxide to serve as a possible carrier of atmospheric oxygen, producing silver oxide in a manner similar to that of the two bodies, manganese dioxide and barium dioxide, liberating oxygen. In the case of lead oxide, No. 14, if dissociation is not possible[1] even at so high a temperature as 1750° C, it seems most reasonable to account for its peculiar oxidizing action, as mentioned above; *viz:* as a carrier of atmospheric oxygen. Although copper oxide has been shown to yield up a part of its oxygen at 1500° C, yet I find no evidence of silver oxide existing in experiment 18 in the remaining ignited mass.

TABLE E.

No. experiment	Ag_2O. in gram.	Heated with	Time of heat	Condition of heat	Per cent Ag. as Ag_2O.
19	0.5	5 grams MnO_2.	60 min.	medium.	36.4
20	0.5	3 " Fe.	60 "	"	0.3
21	0.5	3 " $CaCO_3$.	30 "	"	0.2

In Table E a variation was made in the nature of the experiment. Freshly prepared silver oxide was used; while this oxide was completely decomposed upon being heated gently upon a porcelain lid, yet in No. 19 where manganese dioxide was used, it will be seen that 36.4 per cent. of this silver oxide completely escaped decomposition.

The above results, in connection with others along a similar line, have induced me to believe that attention has not heretofore been directed to the ease with which silver may

[1] *J. Chem. Soc., 65, 316.*

be oxidized by lead oxide, and particularly by substances which give up a part of their oxygen upon gentle ignition, such as manganese dioxide and barium dioxide. Is it not then reasonable to assume that certain losses, or irregularities in the treatment of silver and its compounds, may be due to this cause?

UNIVERSITY OF TENNESSEE.

EXPERIMENTS WITH A DIFFERENTIAL WATTMETER.

By A. B. Reynders.

The losses in a transformer are of importance, though, up to the present, difficult of measurement.

There are seven distinct methods more or less well known and practiced, namely: the calorimeter, dynamometer, three voltmeter, three ammeter, three transformer, wattmeter and the method of using E. M. F. and current curves. All of the above methods have objections, involving either very accurate readings to obtain fairly accurate results, or else expensive and delicate apparatus. The wattmeter method is the one most used at present, and after the application of a correction for self-induction the results are taken as accurate.

A little over a year ago the idea was suggested of making a differential wattmeter, that is, two wattmeters having their suspended coils rigidly connected together, and acted upon differentially by the fixed coils. Such an instrument was constructed at that time. The fixed coils were arranged one pair above the other and in the same vertical plane, the distance between the upper and lower pair being small. The primary current (in this case of low voltage) was passed through the upper fixed coils, while the suspended coil was in shunt with the primary of the transformer to be measured. In the same manner the lower fixed coils were in series with the secondary, while its suspended coil was in shunt with the load. The current was so sent through the coils that the upper pair tended to throw the suspended coil in one direction, while the lower pair tended to throw its suspended coil in the opposite direction. These two suspended coils being rigidly connected together yet insulated from each other, had as a whole very little deflection, and by the proper adjustment of resistances in series with them this deflection may be made zero. A mirror was attached to the suspended coils, and, by means of a telescope and scale, the least motion could be observed.

The actual method of using the differential wattmeter con-

sists in first adjusting the deflection to zero, then calibrating by using a continuous current. By the use of a formula which will soon be deduced we are enabled to find the efficiencies by observing only the various resistances. The adjustment to zero is first accomplished partly by sliding the fixed coils in or out so that there is little deflection, and then reducing this deflection to zero by varying the resistances in series with the suspended coils. After this has been done, and without changing the position of the fixed coils, the instrument is calibrated by using a continuous current, passing the same current through both fixed coils connected in series, and adjusting the deflection to zero by varying only the resistances in series with the suspended coils.

The formula above referred to is found as follows:

Let I_1 = alt. current in fixed primary coils.
i_1 = " " " suspended primary coil.
I_2 = " " " fixed secondary coils.
i_2 = " " " suspended secondary coil.
$I_1{}^1$ = continuous current in fixed primary coils.
$i_1{}^1$ = " " " suspended primary coil.
$I_2{}^1$ = " " " fixed secondary coils.
$i_2{}^1$ = " " " suspended secondary coil.

K_1, K_2=constants of the primary and secondary wattmeters respectively.

R_1, R_2=resistance in primary and secondary suspended coils with alternating current.

$R_1{}^1$, $R_2{}^1$=resistance in primary and secondary coils with continuous current.

d_1, d_2, $d_1{}^1$, $d_2{}^1$=deflection of primary and secondary coils for alternating and continuous currents respectively.

For alternating currents:

$$d_1 = K_1 I_1 i_1 = K_1 I_1 \frac{E_1}{R_1}$$

$$d_2 = K_2 I_2 i_2 = K_2 I_2 \frac{E_2}{R_2}$$

Making the deflection equal to each other or the deflection of the coils differentially connected, zero.

$$K_1 I_1 \frac{E_1}{R_1} = K_2 I_2 \frac{E_2}{R_2}$$

$$\frac{K_1}{K_2} = \frac{E_2 I_2 R_1}{E_1 I_1 R_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

For continuous currents:

$$d_1{}^1 = K_1\ I_1{}^1\ i_1{}^1 = K_1\ I_1{}^1\ \frac{E_1{}^1}{R_1{}^1}$$

$$d_2{}^1 = K_2\ I_2{}^1\ i_2{}^1 = K_2\ I_2{}^1\ \frac{E_2{}^1}{R_2{}^1}$$

Making $d_1 = d_2$ for same reason as given above, and using the same current in both the fixed pair of coils and the same difference of potential at the ends of the suspended coils.

$$K_1\ I_1{}^1\ \frac{E_1{}^1}{R_1{}^1} = K_2\ I_2{}^1\ \frac{E_2{}^1}{R_2{}^1}$$

$$\frac{K_1}{K_2} = \frac{R_1{}^1}{R_2} \text{.....(2)}$$

$$\text{Whence } \frac{R_1{}^1}{R_2{}^1} = \frac{I_2\ E_2\ R_1}{I_1\ E_1\ R_2} \text{ by sub. (2) in (1)}$$

$$\text{Efficiency} = \frac{I_2\ E_2}{I_1\ E_1} = \frac{R_2\ R_1{}^1}{R_1\ R_2{}^1}$$

which is a very easy expression to handle.

The instrument as constructed last year was very unreliable, having nothing to recommend it but its desire to make all transformers have an efficiency greater than unity. The induction of the upper coils on the lower ones and *vice versa*, or, more likely, the direct action of the lower fixed coils on the upper suspended, and *vice versa*, caused a very serious error in the results.

About this time a differential wattmeter, constructed by Prof. Kennelly,[1] came to our notice, and information was immediately sought about his instrument, with the result that we found several sources of error present in the wattmeter which up until then was thought to be original.

Taking advantage of Prof. Kennelly's suggestions, the fixed coils were separated about eight inches and placed at right angles to each other in a new differential wattmeter constructed at the beginning of this year. On testing the instrument for cross induction by passing a current through the fixed coils while the suspended coils were short circuited, no deflection was observed. The instrument was then tried to determine the efficiency of a transformer built in the shops for a capacity of 10 lights, but slightly damaged in some experiments. The transformer was designed to work on an alternating circuit of 20 cycles per second, being used as a step

[1] Electrical Engineer, Dec. 21, 1892.

up, having 10 lights in series on the secondary. The high voltage of the secondary required a high resistance in series with its suspended coil.

At first great difficulty was experienced in obtaining a suitable resistance, and after many substitutes were tried resort had to be made to wire resistances. These resistances were in part constructed in the shops of the University and in part consisted of an ordinary 100,000 ohm box resistance. The coil constructed in the shop was wound non-inductively on a wooden frame 12″ high, 8″ long, 6″ wide, and measured about 42,000 ohms. The resistance box had 10, 20, 30 and 40,000 ohm coils, each wound non-inductively on a a single spool.[1]

In using the instrument with these high resistance coils in series with the secondary suspended coil, fairly consistent results were obtained with the 20-cycle machine, as can be seen from a set of experiments given below:

No. of Exp.	R_1	R_2	R_1^1	R_2^1	Eff.	Volt of Prim.	Load in Lamps on Sec.
13	8370	132,439	6030	142,454	67.0	65	14
14	6360	102,272	6030	142,454	68.0	66	14
15	6120	102,272	6030	142,454	70.7	65	10
16	6360	102,272	6030	142 454	68	65	12
17	6640	112,352	6030	142,454	70.6	65	14

All of the above results were very easily and quickly obtained. Some irregularities were introduced by sparking of the commutator, which finally became so great that these experiments had to be discontinued.

The instrument was next tried on a transformer, using a current of 60 cycles per second, and efficiencies ranging from 83.8 per cent. to 109 per cent. were obtained. Below is given a table which one can see at a glance is totally unreliable.

No. Exp.	Load	Eff.
25	.....(20 lights) full load.....	106.4
26	.....half load.....	101.2
27	.....half load.....	102.8
28	..... one-fourth load	109.4
29	..... one-fourth load	107.0
31	.....full load.....	104.0

[1] As this coil was damaged and repaired, without adjusting, early in the experiments, these values are only approximate. The exact values are of course employed in reducing the results.

It will be noticed that no two measurements on same load agree, but differ about two per cent.

Attention has been called by a number of experimenters to the error that may by introduced by the capacity of resistance coils, and the differences above given have been, largely at least, traced to this cause.

To determine this source of error, an electro-dynamometer was specially constructed and placed in series with the resistances. First the 60-cycle current was sent through the circuit and the deflections noted, and then a continuous current, produced by about the same E. M. F. was used, noting the corresponding deflections. The square root of the deflection divided by the voltage[1] should be the same in both cases if there were no capacity. This was not the case, as can be seen from the following table:

Resistance	Alt. Current Square rt. of Deflection divided by Voltage	Cont. Current Square rt. of Deflection divided by Voltage	Pr. ct. of Alt. Current resist'ce above cont.
132,439	.025	.020	45%
112,394	.028	.028	0
42,110	.061	.055	11%
40,182	.060	.044	36%

The decided differences found in the different experiments correspond with differences in the resistance coils used. In the first and fourth, the 40,000 ohm coil in the resistance box was used. This spool, being compactly wound, had a much greater capacity effect than the similar resistance used in the third experiment, which was wound upon a wooden frame.

No such differences were observed when using the low period current (20 cycles).

Experiments with the differential wattmeter have been carried only to this point, but they are sufficient to show the need of special examination of the coils of wattmeters before they can be used for alternate current measurements, and are sufficient to cast more or less suspicion of inaccuracy upon all wattmeter measurements.

It is also evident that all potentiometer, or other zero methods, as applied to alternate current work, have only a fictitious accuracy. For the strength of the current passing

[1] Measured by an electrostatic voltmeter.

through any coil of wire with a given electromotive force must be determined by direct measurement by means of an electro-dynamometer instead of depending upon resistance comparisons by Wheatstone's bridge.

That such errors have not been more conspicuous in the past is no doubt due to the lower resistances usually employed in such work, but there is no doubt of the possibility of such errors in many of the alternate current voltmeters and wattmeters now employed.

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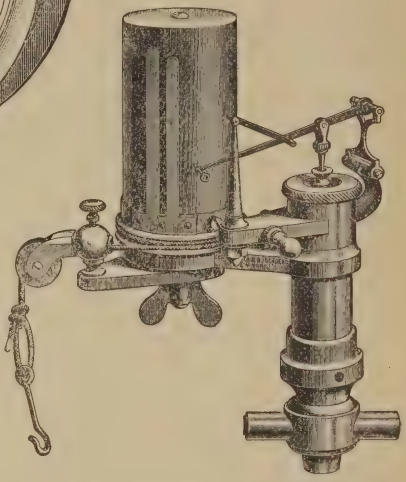

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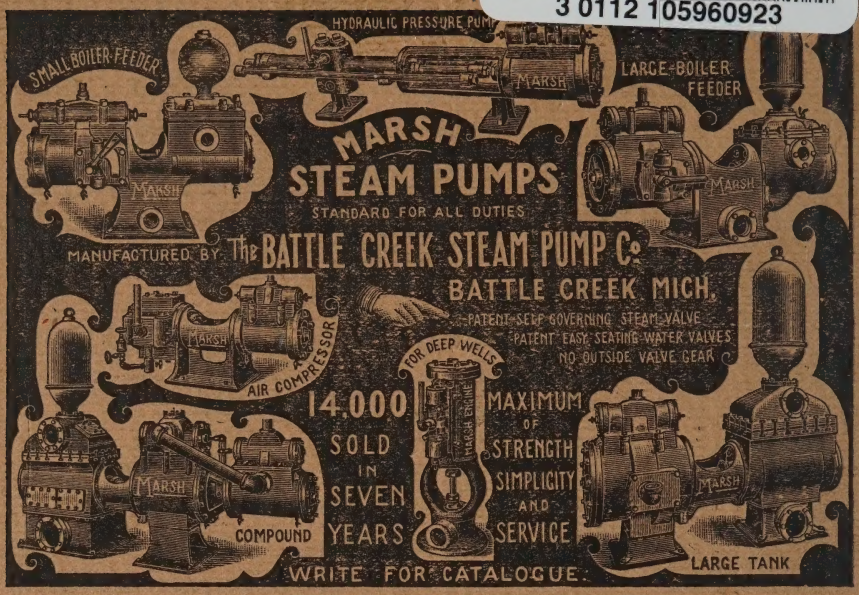

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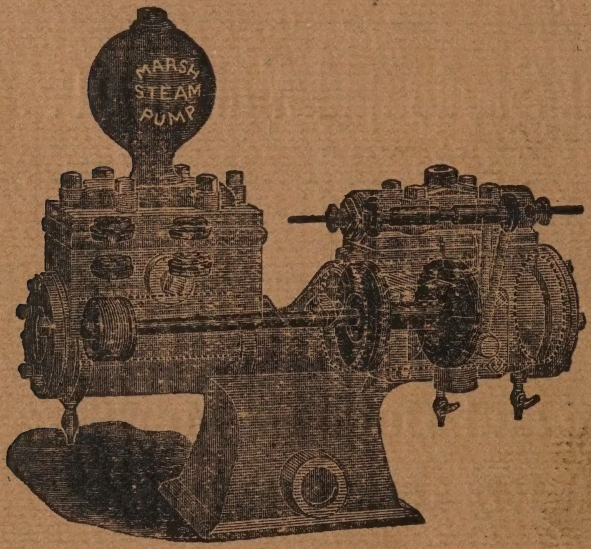

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